

Design and Stress Analysis of a Mixed Flow Pump Impeller

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Abstract: In order to avoid resonance of a mixed flow pump impeller and to avoid blade failure due to excessive stress development, it is required to know the natural frequencies at different modes and one should have an idea about the Von Mises stress distribution in the impeller blades. In this present work design and FEM analysis has been carried out on mixed flow pump impeller having different blade positions on the meridional annulus. The natural frequencies at six different modes of the pump impeller were obtained. The maximum Von Mises stress distribution was compared among the impellers having different blade positions. The mixed flow impeller having inlet inclined blade positions on the meridional annulus experiences less amount of Von Mises stress as compared to impeller having trapezoidal blade positions on the meridional annulus. The natural frequencies of the impeller having inlet inclined blade positions on the meridional annulus shows a higher value as compared to compared to impeller having trapezoidal blade positions on the meridional annulus.

Index Terms— Mixed flow pump, Von Mises stress, FEM analysis, natural frequency

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Nomenclature

$C_{\theta 2}$: tangential component of absolute velocity, m/sec.
 C_c : actual chord, mm.
 C_m : meridional chord, mm.
 C_L : coefficient of lift, dimensionless.
 C_m : meridional velocity, m/sec.
 C_{in} : meridional velocity at inlet, m/sec.
 C_{out} : meridional velocity at outlet, m/sec.
 D_1 : blade diameter at inlet, mm.
 D_2 : blade diameter at outlet, mm.
 D_{1h} : blade diameter at inlet at hub section, mm.
 D_{1t} : blade diameter at inlet at tip section, mm.
 D_{2h} : blade diameter at outlet at hub section, mm.
 D_{2t} : blade diameter at outlet at tip section, mm.
 D_f : Leibniz blade diffusion factor, dimensionless.
 D_m : mean diameter, mm.

e : diameter ratio, dimensionless.
 g : acceleration due to gravity, m/sec².
 H : pressure head, m.
 K_u : velocity coefficient, dimensionless.
 l : blade span, mm.
 N : rotational speed, rev./min.
 P : power, kW.
 Q : volumetric discharge, m³/sec.
 r : radius, mm.
 s : blade spacing, mm.
 v_t : tangential velocity of blade at inlet, m/sec.
 v_b : tangential velocity of blade at outlet, m/sec.
 V_s : slip velocity, mm.
 α_1 : blade inlet angle, degrees.
 α_2 : blade outlet angle, degrees.
 α_m : mean blade angle, degrees.
 λ : blade stagger angle, degrees.
 ρ : mass density of the fluid (water), kg/m³.
 ω : angular velocity, rad/sec.
 Ω : dimensionless specific speed, dimensionless.
 ϕ : semi-cone angle of the impeller, degrees.

1. INTRODUCTION

The mixed flow pumps are extensively used in thermal power plants for cooling water duties. The performance of a mixed flow pump can be considerably improved by applying recent advances in understanding the flow behaviour of the pump and the blades. Thus, optimal blade position in the meridional annulus has an important effect on loss and flow deflection. The objective of the blade design is to realize a given velocity triangle with minimum losses as well as minimum stress development in the blade sections.

The industrial design methods are largely based on the application of empirical and semi-empirical rules along with the use of available information in the form of different types of charts and graphs from the existing literature. Impellers are mainly designed using profile

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